NON-PUBLIC?: N
ACCESSION #: 8905300012
LICENSEE EVENT REPORT (LER)

FACILITY NAME: Arkansas Nuclear One, Unit Two PAGE: 1 of 6

DOCKET NUMBER: 05000368

TITLE: High Pressure Turbine Extraction Steam Line Rupture Due to Pipe Wall Thinning Resulted in a Reactor Trip Caused by High Reactor Coolant System Pressure
EVENT DATE: 04/18/89 LER #: 89-006-00 REPORT DATE: 05/18/89

OPERATING MODE: 1 POWER LEVEL: 100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR SECTION
50.73(a)(2)(iv)

LICENSEE CONTACT FOR THIS LER:
NAME: Dana Millar, Nuclear Safety and
Licensing Specialist TELEPHONE: (501)964-3100

COMPONENT FAILURE DESCRIPTION:
CAUSE: SYSTEM: COMPONENT: MANUFACTURER:
REPORTABLE TO NPRDS:

SUPPLEMENTAL REPORT EXPECTED: No

ABSTRACT:

On 4/18/89, a 14 inch, high pressure turbine extraction steam line ruptured resulting in a reactor trip on high Reactor Coolant System (RCS) pressure. During the transient, the steam turbine driven Emergency Feedwater (EFW) pump tripped on overspeed after receiving an automatic start signal. The 'A' train Feedwater Control System (FWCS) malfunctioned causing a slight overfill of 'A' Steam Generator (SG). One of two Atmospheric Steam Dump Valves (ADVs), located downstream of the SG Main Steam Isolation Valves (MSIVs), could not be opened from the control room. Due to the loss of condenser vacuum, the MSIVs were manually closed and upstream ADVs were used for decay heat removal. One of the upstream ADVs apparently failed open, resulting in a minor unexpected RCS cooldown. The plant was stabilized and a cooldown was performed. The failed line was inspected and the root cause was pipe wall thinning due to erosion-corrosion. Additional extraction steam piping was inspected resulting in several areas being replaced. A degraded ramp generator in the governor speed control circuit of the steam turbine driven EFW pump was replaced. The

'A' train FWCS was found to have some wires with degraded insulation which caused the system to malfunction. The defective wiring was replaced and system tested satisfactorily. The downstream ADV was found to have a galled plug; the plug and stem assembly were replaced. The upstream ADV functioned properly during the cooldown; no cause for its response was identified.

END OF ABSTRACT

A. Plant Status

At the time of occurrence of this event, Arkansas Nuclear One, Unit 2 (ANO-2) was in Mode 1 (Power Operation) with reactor power at approximately 100 percent. Reactor Coolant System (RCS) AB! temperature was 580 degrees Fahrenheit and RCS pressure was approximately 2250 psia. The unit had been operating essentially at full power for approximately 95 days.

B. Event Description

At approximately 0940 on April 18, 1989, a 14 inch extraction steam SE! line from the high pressure (HP) turbine to two HP feedwater heaters SN! catastrophically ruptured resulting in a steam leak under the turbine. Within seconds of the rupture, a fire alarm for the turbine bearing area annunciated in the control room. A control room operator was immediately dispatched to investigate the alarm. Although there was no fire, firewater had automatically actuated to the turbine bearings in the area of the piping rupture. A firewater sprinkler system is utilized for the turbine generator bearings. As a result of the heat generated from the extraction steam line rupture, the fusible heads of the sprinklers melted and firewater flow was initiated to the bearings.

Due to the firewater flow and moisture from the ruptured pipe, the control circuits for the main turbine, located nearby, shorted out causing the turbine generator to trip. A reactor trip occurred at approximately 0941 as a result of high RCS pressure due to the loss of a secondary heat sink. As expected, due to normal post trip response, Steam Generator (SG) water levels decreased to less than 23 percent and an Emergency Feedwater Actuation Signal (EFAS) was generated. The EFAS sends an automatic start signal to both Emergency Feedwater (EFW) pumps BA-P!. ANO-2 has two EFW pumps, one electric motor driven pump and one steam turbine driven. The motor driven EFW pump started automatically and provided feedwater to both SG's. However, approximately 23 seconds after receiving the start signal, the turbine driven EFW pump tripped on overspeed.

With the EFW BA! system operating in an automatic mode, the system is designed to automatically maintain SG water levels by cycling the EFW block valves. While monitoring plant response following the trip, Control Room operators observed that 'A' SG water level was increasing while 'B' SG water level was being maintained by the EFAS. The Reactor Trip Override (RTO) signal within the main Feedwater Control System (FWCS) PL! had not responded correctly. The RTO signal functions to automatically reduce Main Feedwater (MFW) SJ! flow to the SG's following a reactor trip by fully closing the MFW regulating control valves, closing the MFW regulating valves bypass control valves to an approximate 5 percent find demand position, and decreasing the MFW turbine speed controller to a preset minimum speed. Due to a failure in the RTO circuitry, the MFW regulating valve to 'A' SG did not receive a signal to close from the RTO circuitry. This resulted in an excessive post-trip feedwater flow to 'A' SG. The problem was corrected at approximately 0945 when the running MFW pump SJ-P! was manually tripped. Water level in 'A' SG reached a maximum indicated level of approximately 89 percent.

As a result of the extraction steam line rupture, condenser vacuum (SH! began degrading. At approximately 0955, condenser vacuum had decreased to the point where the Steam Dump and Bypass Control System (SDBCS) sent a
close demand signal to the turbine bypass valves to the condenser and an open signal to the downstream Atmospheric Dump Valves (ADV). The SDBCS has three valves that pass steam to the main condenser and four valves that pass steam to the atmosphere, two located downstream of the SG Main Steam Isolation Valves (MSIVs) and two located upstream of the MSIVs. One of the two downstream ADVs failed to automatically respond when it received the signal from the SDBCS to open. The valve controller was placed in manual and the Control Board Operator (CBO) attempted to open it manually; however, this was also unsuccessful. The other downstream ADV was used for decay heat removal.

While attempting to ensure the leak was isolated, at approximately 1014 (about 33 minutes into the event) the MSIVs were closed and two ADVs located upstream of the MSIVs were manually opened for decay heat removal. With an approximate 20 percent open demand signal to one of the ADVs, RCS temperature and SG pressure began to decrease abnormally. The rate at which the decrease was occurring seemed to indicate the valve was full open rather than at the demand indicated. A motor operated isolation valve for the ADV was shut securing steam flow through the valve which terminated the RCS temperature and SG pressure decrease. RCS temperature decreased to a minimum of 522 degrees and SG pressure decreased to approximately 792 psia prior to terminating steam flow through the ADV.

At approximately 1017, the trip throttle valve for the turbine driven EFW pump was reset. The pump was then started and aligned to feed the steam generators. Using one or both of the upstream ADVs as needed for decay heat removal, a Plant Cooldown to Cold Shutdown was commenced at about 1158.

On April 19, 1989, at 0137, ANO-2 was in Operational Mode 5 (Cold Shutdown)

C. Safety Significance

Several malfunctions of plant equipment occurred following the reactor trip which complicated the event and the required response of the Operations staff to the transient. However, none of the failures significantly affected the capability of the Operations staff to respond to the transient or resulted in unsafe plant conditions. The rupture of the high pressure extraction line did not result in any serious equipment damage nor in any personnel injury.

The post-trip response of the primary system was as expected for this type of event, with the exception of the minor RCS overcooling as a result of a malfunction of the SDBCS upstream ADV. RCS temperature was returned to the normal value of approximately 545 degrees following prompt operator identification of the problem and corrective action to isolate the ADV. There were no RCS inventory problems as a result of the overcooling. The minimum pressurizer water level observed was approximately 24 percent.

The unavailability of the steam turbine driven EFW pump immediately following the Reactor trip did not result in an inability to supply feedwater to the steam generators. Adequate steam generator water inventory was maintained for decay heat removal with the electric motor driven EFW pump, which remained operable throughout the event. The steam turbine driven EFW pump was restored to an operable condition within approximately 36 minutes of its initial failure.

The plant was safely stabilized in Mode 3, Hot Standby. A cooldown followed placing the plant in Mode 5, Cold Shutdown.

D. Root Cause

o High Pressure Turbine Extraction Steam Line Failure
(See attached drawing)

Following the event, a detailed investigation and review of the failed piping associated with the High Pressure Turbine Extraction steam line was

conducted. This review identified that the inside surface of the pipe exhibited extensive thinning around the circumference where the rupture occurred. There was also a circumferential bulge at or near the location of the failure. The bulge was apparently caused by plastic yielding of the thinned pipe at some time prior to the rupture. The failure occurred at the entry point into the pipe from the high pressure turbine extraction nozzle. This area is a region of great turbulence of steam flow in the pipe. The piping inside diameter surface, in the thinned areas around the rupture, exhibited patterns of scalloped pitting. These features extended a few inches or more downstream from the rupture. Also, the scalloped area spanned approximately one-half of the pipe circumference along the line of fracture. Unmistakable characteristics of erosion-corrosion were exhibited on the scalloped area of the pipe's inside diameter.

The nozzle material, which reportedly contains about 0.38 percent copper to retard erosion-corrosion, had several broad, shallow grooves on its inside surface. It appeared that these grooves were oriented with the flow of the incoming extraction steam. Thus, it is believed that these shallow groves were a result of erosion-corrosion from the steam.

At several locations downstream of the rupture, the pipe's inside surface appeared to have sustained metal removal. In one area, there may be a form of erosion-corrosion known as "tiger striping." This will be examined more thoroughly when the pipe can be cut apart. Other areas on the pipe inside diameter appeared to have a protective oxide, presumably magnetite. There did not appear to be any corrosion pitting, deposits, or foreign substances particularly in the region of the rupture.

It was concluded from the study of the pipe that the root cause of the rupture of the pipe was caused by pipe wall thinning due to erosion-corrosion. A contributing cause was determined to be a slight mismatch in the piping inside diameter and extraction nozzle inside diameter at the point of the weld joining the two components.

o Steam Turbine Driven EFW Pump Overspeed

When an EFAS signal is received, a bypass valve around a normally closed main steam isolation valve in the steam line to the turbine opens and the turbine accelerates to a minimum idle speed of approximately 800 RPM. After a time delay of about 17 seconds, the main steam isolation valve is designed to open. Simultaneously with this, the turbine governor ramp generator should accelerate from idle speed to a rated speed of 3780 RPM in approximately 15 seconds. Post trip investigation of the overspeed trip of the steam turbine driven EFW pump identified that the ramp time in

the governor ramp generator signal converter module had drifted from 15 seconds to 3 seconds. Since the ramp time in the ramp generator was reduced to approximately 3 seconds, the turbine accelerated too rapidly and tripped on overspeed.

o Malfunction of Reactor Trip Override Circuitry

An investigation of the malfunction of the RTO circuitry to the FWCS revealed that a wire associated with the RTO circuit seal-in relays for 'A' train FWCS shorted to ground. For the RTO signal to stay in when received, two of three RTO seal-in relays must stay energized. The shorted wire prevented two of the three relays from being energized. The insulation of the wire was apparently damaged during original installation and had finally broken down over time allowing the wire to short to ground. No problem was found with the wiring for the RTO circuitry for 'B' train FWCS.

o Atmospheric Dump Valve Which Did Not Operate Properly

The ADV that did not open properly in automatic or manual was found to have a galled plug which caused binding of the valve preventing it from opening. The upstream ADV that had failed open, causing the slight RCS cooldown and SG depressurization, subsequently started operating properly and was used during the cooldown of the plant from Mode 3 to Mode 5. No root cause for the initial problem with this valve during the transient could be determined.

E. Basis for Reportability

This event included automatic actuations of ESF and RPS and is therefore reportable per the requirements of 10CFR50.73(a)(2)(iv). A four-hour report to the NRC Operations Center was made concerning this event in accordance with 50.72(b)(2)(ii) at 1040 on April 18, 1989.

F. Corrective Actions

o High Pressure Turbine Extraction Steam Line Failure

In March 1987, as a response to NRC Bulletin 87-01 "Thinning of Pipe Walls in Nuclear Power Plants", a task group was organized to establish an inspection program to monitor secondary system piping for wall thinning in order to enhance plant safety and reliability. The scope of the program included those piping locations which were believed to be susceptible to erosion-corrosion induced wall thinning. One of the systems involved in this inspection program is the HP turbine extraction steam system. During a Refueling Outage in 1988, an inspection was made on a portion of the

piping that ruptured, however, the vertical run of piping from the extraction nozzle to the first elbow was not inspected. The rupture occurred in this vertical run of piping. The selection of previous inspection locations had been based on engineering judgement and the vertical run of piping was not considered to be a highly susceptible area for pipe wall thinning.

After the extraction steam line rupture, the vertical runs of piping from the high pressure turbine extraction nozzles to the first elbow in the piping were inspected and subsequently replaced. Other piping was inspected based on engineering judgement and recommendations from Electric Power Research Institute (EPRI). As a result of these additional inspections, several additional areas of piping were also replaced.

o Steam Turbine Driven EFW Pump Overspeed

The governor ramp generator signal converter module was replaced on the steam turbine driven EFW pump. A complete calibration of the speed circuitry was performed and reverified to ensure that the time in the ramp generator remained at 15 seconds. An overspeed trip test was performed satisfactorily on May 5, 1989, and the monthly test of the pump was satisfactorily completed on May 7, 1989.

o Malfunction of Reactor Trip Override Circuitry

The defective wires in the RTO circuitry for the 'A' train of the FWCS were replaced. The redundant FWCS was inspected for any similar problems, none were identified. The RTO circuitry was tested and verified to work properly.

o Atmospheric Dump Valve Which Did Not Operate Properly

The plug and stem of the downstream ADV were replaced during corrective maintenance. The valve was stroked several times without binding. Investigate of the opening of the upstream ADV did not determine a root cause, no corrective action was performed. A surveillance procedure is being developed and will be implemented to stroke the valves in the SDBCS.

G. Additional Information

o Similar Events

There are no previously reported similar events related to secondary system piping ruptures caused by pipe wall thinning.

o Supplemental Information

Energy Industry Identification System (EIIS) codes are identified in the text as XX!.
TEXT PAGE 6 OF 6

FIGURE OMITTED - NOT KEYABLE (DRAWING)

ATTACHMENT 1 TO 8905300012 PAGE 1 OF 1

AP&L
ARKANSAS POWER & LIGHT COMPANY

May 18, 1989

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U. S. Nuclear Regulatory Commission
Document Control Desk
Mail Station P1-137
Washington, D.C. 20555

SUBJECT: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Licensee Event Report No. 50-368/89-006-00

Gentlemen:

In accordance with 10CFR50.73(a)(2)(iv), attached is the subject report concerning a high pressure turbine extraction steam line rupture due to pipe wall thinning resulting in a reactor trip caused by high Reactor Coolant System pressure.

Very truly yours,

E.C. Ewing
General Manager,
Plant Support

ECE:DM:sgw
attachment

cc w/att: Regional Administrator
Region IV

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